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$\mathrm{L_{UV}} T_{\rm eff} t_{\rm th} t_{\rm visc} F_{\rm x} F_{\rm m} F_{\rm d} F_{\rm rad} \tau_{\rm x} P_{\rm mag} V_{\rm A} P_{\rm rad} P_{\rm gas} P_{\rm tot} \dot{m}_{\rm s} L/L_{\rm Edd} \lesssim \gtrsim \dot{m}_{\rm t} \dot{m}_{\rm cr} \dot{m}_{\rm h} \dot{m} T_{\rm eff} - \Sigma$
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Time-Dependent Disk Models for the Microquasar GRS 1915+105

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abstract During the past two years, the galactic black hole microquasar GRS 1915+105 has exhibited a bewildering diversity of large amplitude, chaotic variability in X-rays. Although it is generally accepted that the variability in this source results from an accretion disk instability, the exact nature of the instability remains unknown. Here we investigate different accretion disk models and viscosity prescriptions in order to provide a basic explanation for the exotic temporal behavior in GRS 1915+105.

We discuss a range of possible accretion flow geometries. Based on the fact that the overall cycle times are very much longer than the rise/fall time scales in GRS 1915, we rule out the geometry of advection dominated accretion flow (ADAF) or a hot quasi-spherical region plus a cold outer disk for this source. A cold disk extending down to the last inner stable orbit plus a hot corona above it, on the other hand, is allowed.

We thus concentrate on geometrically thin (though not necessarily standard) Shakura-Sunyaev type disks (Shakura & Sunyaev 1973; hereafter SS73). We argue that X-ray observations clearly require a quasi-stable accretion disk solution at high accretion rates where radiation pressure begins to dominate, which excludes the standard α-viscosity prescription. To remedy this deficiency, we have therefore devised a modified viscosity law that has a quasi-stable upper branch, and we have developed a code to solve the time-dependent equations to study such an accretion disk. Via numerical simulations, we show that the model does account for several gross observational features of GRS 1915+105, including its overall cyclic behavior on time scales of $\sim$ 100 - 1000 s. On the other hand, the rise/fall time scales are not short enough, no rapid oscillations on time scales 10 s emerge naturally from the model, and the computed cycle-time dependence on the average luminosity is stronger than is found in GRS 1915+105.

We then consider, and numerically test, several effects as a possible explanation for the residual disagreement between the model and the observations. A hot corona with the energy input rate being a function of the local cold disk state and a radius-dependent α-parameter do not appear to be promising in this regard. However, a more elaborate model that includes the cold disk, a corona, and plasma ejections from the inner disk region allows us to reproduce several additional observed features of GRS 1915+105. We conclude that the most likely structure of the accretion flow in this source is that of a cold disk with a modified viscosity prescription, plus a corona that accounts for much of the X-ray emission, and unsteady plasma ejections that occur when the luminosity of the source is high. The disk is geometrically thin due to the fact that most of the accretion power is drained by the corona and the jet.